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SAFE MECHANICAL EQUIPMENT FOR USE IN SHAFT SINKING

BY

R. H. KUDLICH

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

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First edition, May, 1922.

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SAFE MECHANICAL EQUIPMENT FOR SHAFT SINKING.

By R. H. KUDLICH.

INTRODUCTION.

Shaft sinking has always been considered more hazardous than the mining operations that are carried on after the period of sinking and development.

Although many States have mining laws requiring that certain precautions be taken to reduce the inherent hazards of shaft sinking as much as possible, other States have not passed such laws. Furthermore, since more than 10 men seldom work in a shaft simultaneously during sinking operations, the mine inspectors of several States with safety laws have no jurisdiction over sinking operations, in so far as such operations are covered by the general mining laws.

In sinking a shaft, the actual work of drilling, blasting, and mucking is so similar to that of ordinary mining that no special equipment or instructions are necessary.

VENTILATION.

Natural ventilation, assisted by the air exhausted from the drills or allowed to escape from the air pipe, usually suffices to keep the air in circulation and to blow out the smoke after a blast, except in shafts that are deep or those in which gas is likely to be encountered when the coal seam is approached. Artificial ventilation is necessary in such shafts. The simplest ventilating sytem is an air duct of light sheet metal, or of wood or canvas, that has a sectional area sufficient to carry the required amount of air and that can be extended downward to the lowest set of timbers as sinking proceeds. The air may either be drawn up through the duct by a steam jet or forced down by a blower fan. The latter method is preferable, as fresh air is forced nearer the bottom of the shaft and the circulation is more positive.

DANGER FROM FALLING MATERIAL.

The principal hazards peculiar to shaft sinking are incurred when the excavated material is hoisted, by more or less temporary equipment, above the men working in the shaft with practically no protection from falling material.

Accidents are caused most frequently by the bucket striking against the timbers or walls of the shaft as it is being hoisted or lowered and

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becoming detached from the hook that holds it to the rope. Other accidents result from the bucket overturning or from the rope or its fastening pulling out. These can almost entirely be eliminated by erecting a rigid headframe and installing guides as sinking progresses and by using proper crossheads, safety hooks, and buckets.

NEED OF HEADFRAME AND GUIDES.

The types of accidents mentioned above can be prevented only by the use of such equipment as will insure hoisting the bucket in the center of the shaft, or a compartment of the shaft, and will prevent it from swinging against the timbering or sides. Primarily this result can be accomplished only by using a fixed head sheave mounted in a headframe. When a swinging-boom derrick is employed, as in some mining regions, there is always the danger that the boomhead is not centered above the shaft when the bucket is being lowered, or that the boom may swing from its proper position as a load is being hoisted or lowered, because of a brake slipping or some rope or connection breaking.

Although the bucket is suspended from a point over the center of the shaft, it is very likely to swing against the timbers or walls of the shaft, especially during hoisting, unless restrained by guides. In the hurry of removing the muck before another round has been drilled and prepared for blasting, time is seldom taken to center the bucket properly before the signal to hoist is given. Although the swinging of the bucket may be slight at the beginning of the hoist, there is always a possibility of its being accelerated by irregular hoisting or by air currents until it brings the bucket in contact with the shaft timbering.

DEFECTS OF SIMPLE CROSSHEAD.

The crosshead is intended primarily to prevent the bucket from swinging while being hoisted or lowered and from coming in contact with the timbers or walls of the shaft. In its crude form, the crosshead is simply a vertical rectangular frame with shoes to fit the two shaft guides at its four corners, and some means of steadying the rope to prevent it from swinging. This crosshead rests on a clamp attached to the hoisting rope a short distance above the bucket, and descends with the rope until it encounters blocks bolted to the guides at their lower ends; there it stops while the rope passes on through the crosshead until the bucket reaches the shaft bottom. A crosshead of this type fills the ordinary requirement of guiding the bucket in a straight line but does not take care of such emergencies as the rope breaking or the crosshead jamming on the guides in the shaft.

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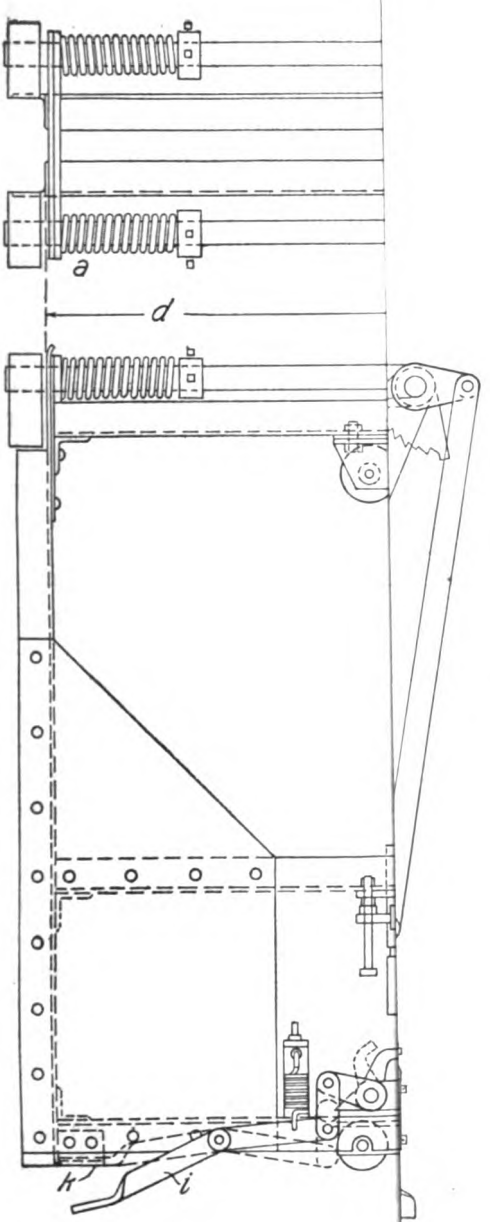

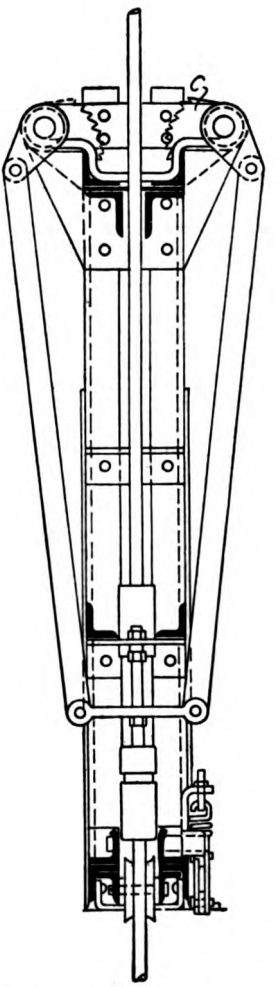

Safety crosshead for shaft-sinking buckets: *a*, T inch plus **width of guides; *f*, 2-inch steel shafts;** *g*, not less than distan inch wrought iron.

NOTE.—All frame and connecting angles 3 by

97365°—22. (Faces p. 2.)

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DESCRIPTION OF SAFETY CROSSHEAD.

A crosshead that will tend to prevent accidents from these causes is shown in Plate I. It is equipped with safety catches that will engage the guides and support the crosshead and bucket if the rope breaks. The latch on the lower horizontal member engages a button clamped to the rope and prevents the bucket from descending while the crosshead is stationary at any point, except at the bottom of the guides when the crosshead is resting on the stop blocks.

With the exception of the safety catches, this crosshead may be built of standard structural material. The necessary tools are a drill press, a small lathe, oxyacetylene cutting and welding equipment, and a forge; specialized workmanship is not needed. The safety catches may be purchased from practically any machineshop manufacturing mining equipment.

The frame is built of angle irons (3 by 3 by $\frac{3}{16}$ inch for buckets of ordinary sizes) connected with angle irons and reinforced with one-fourth inch gusset plates. The plates through which the safety-catch shaft passes should be heavy enough to resist the spreading tendency of the catch, and they should be fastened to the vertical members strongly enough to hold the weight of the loaded bucket if it is brought to rest suddenly when falling at considerable speed. The ends of the vertical angles that serve as guide shoes should be well flared at the ends to pass readily any inequalities in the shaft guides.

The safety catches are operated by the spring drawhead whose detailed construction is shown in Figure 1. This drawhead is made of two pieces of wrought-iron pipe. The larger pipe ($2\frac{1}{2}$ inches diameter) has a head with a $1\frac{1}{4}$-inch hole in it welded into one end and a plate by which it is bolted to the frame welded around it near the center. A 2-inch smaller pipe slides into the larger one, with a plate on which the reach-rod pivots are formed welded to one end. The coiled spring housed in these pipes should have just enough compressive strength to force the two pipes apart and prevent them from binding on each other. The two long bolts act as guides and prevent the pipes from being pushed entirely apart by the spring, while the upper nut and the pipe spacers prevent them from being pushed too far into each other and crushing the spring.

The tension of the safety-catch springs coiled around the shafts should be adjusted by rotating the set-screw collars, so that the safety catches will be turned out to their disengaged position with a pull of about three-fourths of the weight of the crosshead against the drawhead.

The safety catches shown have cast teeth extending entirely across the face of the cam. Such teeth have good gripping power on dry clean guides, but are not satisfactory on wet slippery guides,

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where the space between the teeth is likely to fill up with wood shavings and pulp, with the result that the teeth slide along the surface of the guide instead of pulling themselves in. To prevent such slipping it is well to insert sharpened studs of wrought iron (¾ inch round) between the teeth. The sharp points will penetrate the slippery surface of the guides and tend to pull the cams around so that the flat teeth grip the guide and bring the crosshead to rest.

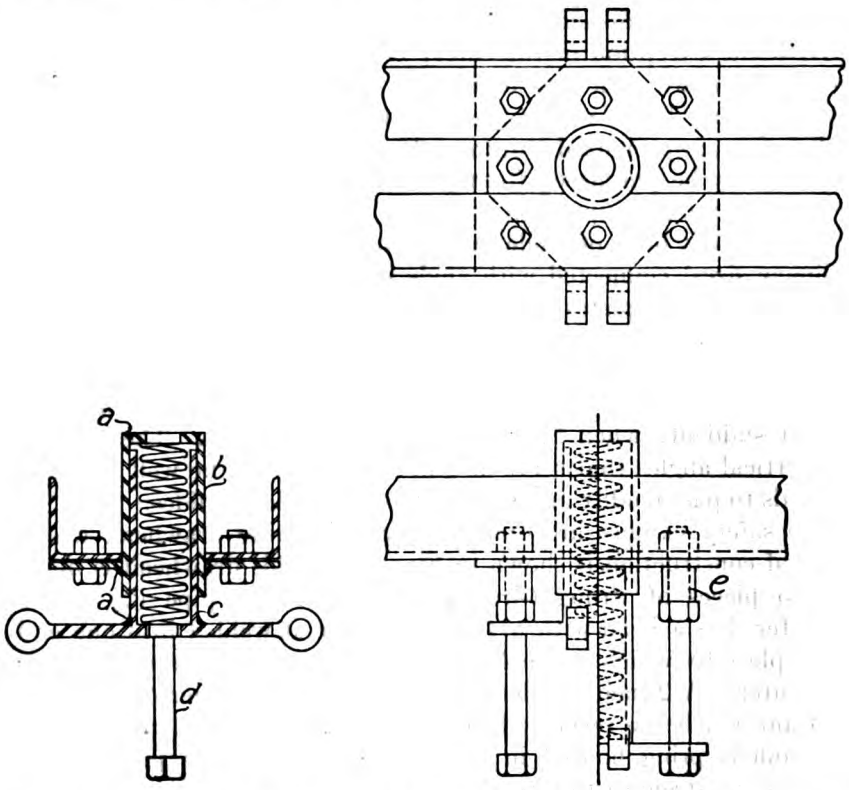

FIG. 1.—Detail of drawhead: *a*, Welded joints; *b*, 2½-inch wrought pipe; *c*, 2-inch wrought pipe; *d*, ¾-inch guide bolts; *e*, ¾-inch pipe spacer.

The latch mounted on the lower member of the crosshead serves the double purpose of preventing the crosshead from sticking in the shaft (elsewhere than at the foot of the guides) while the bucket continues to descend, and of supporting the bucket if the rope should break and the safety catches engage.

The latch consists of two pawls held toward each other by the springs, except when the crosshead rests on the stop blocks; then the levers pivoted on the bottom member are raised by the blocks to the position shown by the broken lines in Plate I and the pawls are thrown back to allow the button clamped to the rope to pass.

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The details of the rope button are shown in Figure 2. This is designed so that the four sets of annular wedge rings give a firm grip on the rope, but can be easily loosened when the rope has to be cut off and resocketed. A rope button of this design, clamped on a 1-inch, 18-strand, 7-wire, nonspinning steel rope and drawn tight with a 48-inch wrench, sustained a load of 2 tons dropped a distance of 14 inches without slipping and slipped under a gradually applied load of 13.2 tons.

A simpler button may be made by slipping a piece of 2½-inch pipe about 8 inches long with ends peened in over the rope and filling it with melted zinc, as in casting a socket. This method is, however, likely to injure the rope by burning out the hemp core, and by annealing, and thereby weakening, the wires where they have been heated by the hot zinc.

DANGER OF USING OPEN HOOK.

In shaft sinking, the buckets are usually hooked to the rope, since the rope must be disconnected from a bucket each time it is landed. Although the dangerous practice of using an ordinary open hook should not be permitted, nevertheless it is altogether too common.

If an open hook is used, the bucket may become unhooked by striking something while being lowered or by slipping while being dumped and catching only on the tip of the hook. From this latter position the bucket may easily become detached by the twisting of the rope or the jerking of the engine. Only safety hooks, which can not be unintentionally disengaged, even when the rope is slack, should be used in shaft sinking.

DESCRIPTION OF SAFETY HOOKS.

Seven types of safety hooks and one safety clevis are shown in Figure 3. The simplest one to make is the pigtail hook, a type successfully used in the Joplin zinc district where hoisting with buckets in vertical shafts is common. The pigtail hook is easily manipulated, but should the rope be slackened so that the position of the hook is inverted, it may become detached as the rope is drawn taut again.

The sister hooks are simple and efficient, but both hands are needed to adjust them, which is often inconvenient.

The hook with a weighted latch, shown in Figure 3 with a safety handle to prevent injuring the hand, may be used with one hand. It is almost impossible for such a hook to be disengaged unintentionally. There is, however, some likelihood of the latch being rendered inoperative by becoming bent or clogged with dirt.

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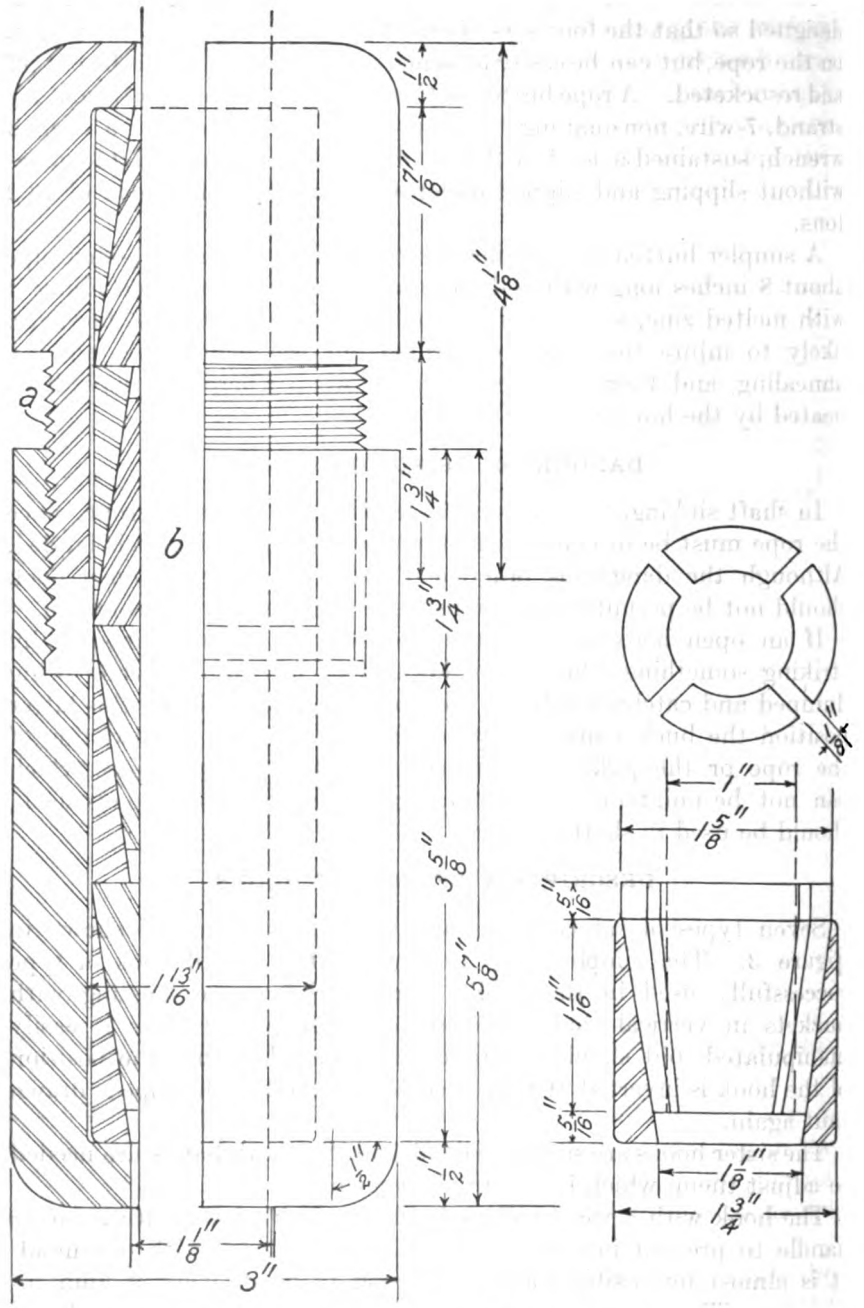

Casing, one required, machine steel.

Wedge ring, four sets required, machine steel.

FIG. 2.—Detail of rope button: *a*, 2½-inch thread—8 threads per inch; *b*, 1-inch nonspinning wire rope—18 strands, 7 wires.

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FIG. 3.—Safety hooks and clevis for shaft-sinking bucket: *a*, Pigtail hook; *b*, Foundation Co. safety hook; *c*, hook with weighted latch; *d*, chain hook; *e*, sister hook; *f*, hook with spring latch; *g*, safety clevis; *h*, hook with sleeve latch.

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The hook with a spring latch is used in many mining districts. The body is made of wrought iron or steel and the spring latch of tempered steel. This spring is the possible weak feature, since it may break or become bent back if it is not properly made and tempered and may not resume its normal position when released, in either case failing to close the throat of the hook.

The chain hook which, with its chain, is passed through a ring on the rope and the bail of the bucket requires somewhat longer to engage and disengage, but unless the hook is opened by overstraining there is little likelihood of its coming loose. The Foundation Co. safety hook is practically positive in its action unless the hook becomes so strained that the tongue of the latch will not enter the slot in the hook, when it becomes useless.

The pin of the safety clevis must be turned half around, until the handle is pointed up, before it may be withdrawn to detach the bucket, making the chance of unintentional disengaging very remote, but the pin and the lug may become so battered by the rough treatment the clevis receives that it can be manipulated only with difficulty.

The sleeve latch is a piece of pipe slipped on the hook before it is entirely formed; this closes the hook when pushed down over the opening to the position shown. If the pipe sleeve is so turned that the pins are not in line with the slot it is impossible for the sleeve to slip up and bare the opening. The sleeve is, however, likely to become battered or clogged with dirt and grit, and thus fail to slip down properly.

SINKING BUCKET COMMONLY USED.

The type of bucket commonly used in shaft sinking, sketched in the upper part of Figure 4, is another source of danger. Such a bucket is suspended from a bail, which is attached to the bucket below its center of gravity by trunnions or pivots, and is prevented from overturning while being hoisted by latches on the side of the bucket.

Should the latches become bent or be jarred loose by continued use, or should the bucket catch during hoisting and the latches bend enough to clear the bail, the bucket will overturn and its contents will drop on the men working at the bottom of the shaft.

TYPE OF SINKING BUCKET RECOMMENDED.

A much safer bucket is one that has the bail so pivoted at or near the top that it will retain its upright position by gravity. Such a bucket may be emptied into a dump chute built into the headframe by means of a "bull chain" hooked into the ring at the bottom of the bucket and so arranged that, as the weight of the bucket is

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transferred from the hoisting rope to the bull chain, the bucket is carried from its position over the shaft to one over the dump chute and then overturned. The bucket may also be lowered on a dumping truck which has slotted posts to support the bucket, with the slots holding the trunnions, and may be kept upright by a suitable latch while the truck is being pushed out to the dump. Either method of dumping requires little more time and effort than dumping by the ordinary method, and is much safer.

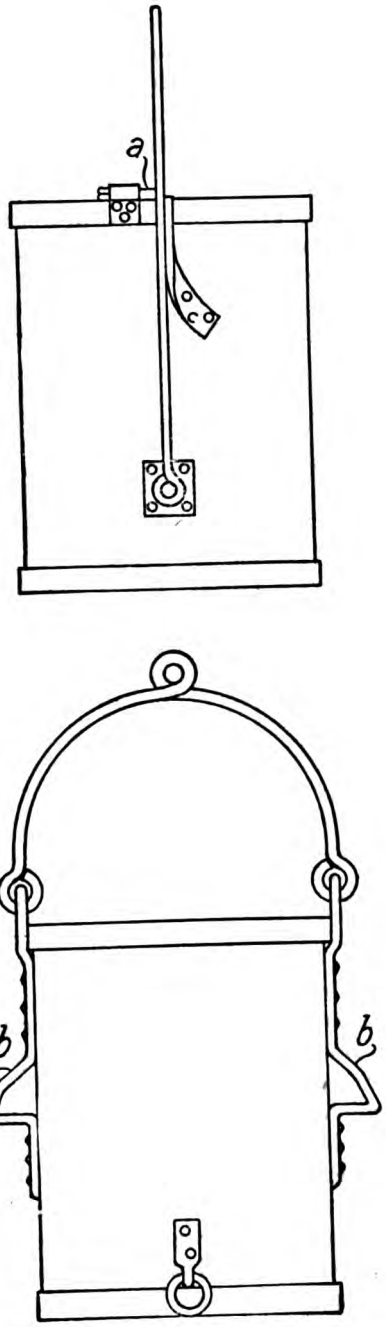

FIG. 4.—Above, common type of bucket; below, type of bucket suggested: *a*, Latch on each side to hold bail upright; *b*, lugs. Scale—¾ in.=1 ft.

PLATFORM COVERING SHAFT.

In order to prevent men or material from falling down the shaft, a substantial platform should be built to cover it entirely, with a hole only large enough to allow the safe passage of the bucket. The cross joists on which the planking is laid may rest on the top of the shaft cribbing or collar, as shown in Figures 4 and 5, or they may be carried on stringers supported a short distance above the collar. In either construction the spaces between the ends of the joists should be left open for ventilation. The joists should extend beyond the outside edge of the shaft timbers and the planking be carried to the end of the joists to prevent anything from falling into the shaft at that point. Access to the ladder and pipe compartment is given by a trapdoor just large enough to admit a man.

The hoist opening in the platform should be protected with

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railings and gates, or bars and toe boards, and should be covered with substantial hinged doors that must be kept closed except when the bucket is being hoisted or lowered through the opening. Especial precautions should be taken that the doors be closed each time the bucket is being dumped or set on the truck, or when tools, timber, or blasting materials are being loaded into the bucket.

DOORS FOR PLATFORMS.

Two types of platform doors are shown in Figures 5 and 6. The first or flat door is preferable when a truck is used and when the bucket is to be landed on the door for loading tools. The gable type

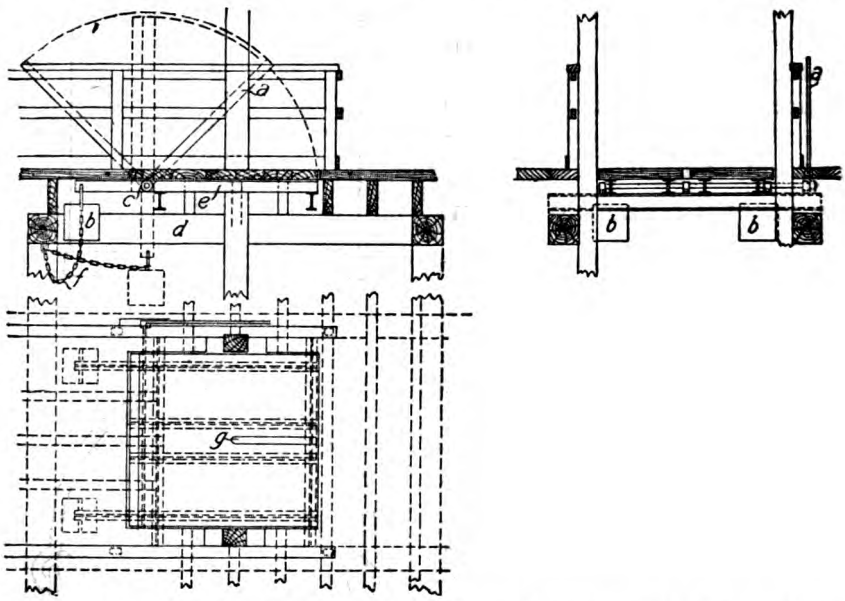

FIG. 5.—Flat door for shaft-sinking platforms: *a*, Operating lever; *b*, counterweight; *c*, hinge shaft; *d*, shaft cribbing; *e*, 4-inch I beams; *f*, safety chain; *g*, slot for hoisting rope.

of door is easier to operate but interferes somewhat with loading material and handling timber into the shaft.

Both types of doors are keyed to shafts which act as hinges and are operated by systems of levers acting on the ends of the shafts which project at one or both sides, depending on the position occupied by the dumper and the method of dumping or handling tools and materials. The levers may be made operative from some remote point, say at the dump chute, by ropes or reach rods.

The flat door must be strong enough to sustain the largest piece of rock handled when dropped from the point where the bucket is dumped. It has been found in practice that for ordinary doors 3 or 4 inch I beams as stringers with 2 or 3 inch oak planks are suitable. A door of this type is so heavy that it must be counterweighted. As shown in the sketch the counterweights are carried

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on extensions of the door stringers and hung over the shaft. Each counterweight so used must be in one piece (an iron box or bucket filled with scrap iron and the interstices filled with neat cement grout is satisfactory) with its bail securely anchored into the mass, and should be provided with a heavy safety chain that will catch the counterweight, should it work loose from its ordinary fastenings, and prevent its falling into the shaft.

A gable-type door may be of lighter construction (2-inch plank with 3 by ½ inch strap iron battens will do), as falling rock will not strike it a direct blow. Doors of this kind are connected by a suitable linkage that will operate both doors simultaneously, and they should be so fitted with stops that they fall only a short distance beyond the

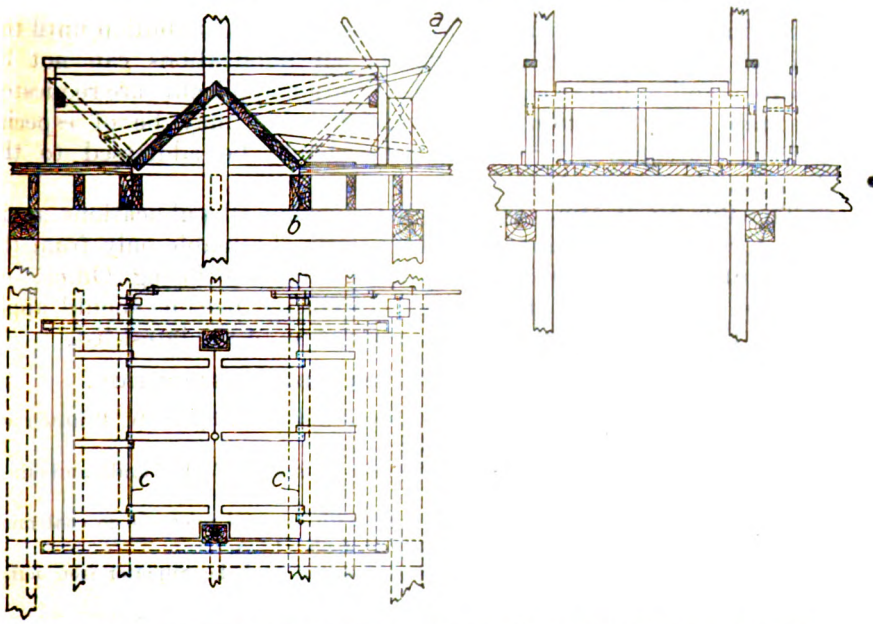

FIG. 6.—Gable doors for shaft-sinking platforms: *a*, Operating lever; *b*, shaft cribbing; *c*, hinge shaft.

vertical when opened; then it will be found that these doors can be operated unbalanced without undue effort.

RESPONSIBILITY OF WORKMEN.

Although the equipment described above will go far toward reducing hoisting dangers in shaft sinking, such dangers can only be eliminated by constant vigilance on the part of the hooker-on at the shaft bottom, and of the dumper at the surface. The hooker-on must be sure that the bucket is in good condition, not overloaded, properly attached to the rope, and well steadied before the final hoisting signal is given.

The dumper must inspect the entire headworks, examining the headframe, sheave and sheave supports, and crosshead with its latches and safety catches, for breakage or loosened connections,

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and must examine the ropes for wear, broken wires, and slippage of clamps. He must also keep loose material from accumulating at places from which it may fall or be knocked into the shaft. He must be responsible for the shaft doors being closed at all times except when they must be opened to hoist or lower the bucket, and the gate or bars closed except when tools or material are bring brought to the shaft. In addition he must, like the hooker-on, see that the bucket is in good condition, not overloaded, properly attached to the bucket, and well steadied before the final signal to lower is given.

PUBLICATIONS ON SAFETY EQUIPMENT FOR MINES.

(List does not include publications on lights and electric motors.)

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PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION.

BULLETIN 57. Safety and efficiency in mine tunneling, by D. W. Brunton and J. A. Davis. 1914. 271 pp., 6 pls., 45 figs.

BULLETIN 75. Rules and regulations for metal mines, by W. R. Ingalls and others. 1915. 296 pp., 1 fig.

BULLETIN 99. Mine-ventilation stoppings, with especial reference to coal mines in Illinois, by R. Y. Williams. 1915. 30 pp., 4 pls., 4 figs.

TECHNICAL PAPER 30. Mine-accident prevention at Lake Superior iron mines, by D. E. Woodbridge. 1913. 38 pp., 9 figs.

TECHNICAL PAPER 103. Organizing and conducting safety work in mines, by R. M. Wilson and J. R. Fleming. 1917. 57 pp., 35 figs.

TECHNICAL PAPER 174. Suggestions for the safe operation of gasoline engines in mines, by R. H. Kudlich and Edwin Higgins. 1917. 19 pp., 3 figs.

TECHNICAL PAPER 229. Accident prevention in mines at Butte, Mont., by Daniel Harrington. 1920. 59 pp., 2 pls.

TECHNICAL PAPER 237. Safe practice in using wire ropes in mines, by O. P. Hood and R. H. Kudlich. 1919. 9 pp.

TECHNICAL PAPER 251. Ventilation in metal mines, by Daniel Harrington. 1921. 44 pp.

MINERS' CIRCULAR 13. Safety in tunneling, by D. W. Brunton and J. A. Davis. 1913. 19 pp.

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TECHNICAL PAPER 67. Mine signboards, by Edwin Higgins and Edward Steidle. 1913. 15 pp., 1 pl., 3 figs. 5 cents.

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